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AGRICULTURAL NEWS LETTER

VOL. 5 - NO. 9 SEPTEMBER, 1937

This publication gives information on new developments of interest to agriculture on laboratory and field investigations of the du Pont Company and its subsidiary companies.

In addition to reporting results of the investigations of the Company and its subsidiaries, published reports and direct contributions of investigators of agricultural experiment stations and other institutions are given dealing with the Company's products and other subjects of agricultural interest.

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AGRICULTURAL NEWS LETTER

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IMPROVEMENTS IN COMMERCIAL FERTILIZERS DESCRIBED AND MEANS FOR FURTHER BETTERMENT SHOWN IN REPORT

EDITOR'S NOTE:- This article is reprinted from "Technological Trends and National Policy," a report of the Subcommittee on Technology to the National Resources Committee. The Honorable Harold L. Ickes, Secretary of the Interior, is chairman. The article appears under the title "Chemical Fertilizers." It is by Dr. A. R. Merz, Chemist, Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C.

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The cultivation of plants for sustenance dates from the remote past. In the course of ages, knowledge was gained fortuitously that the growth of vegetation was promoted by the addition to the soil of certain materials and that the continued raising of crops without such additions frequently resulted in decreased yields.

Although the Romans were aware of the social, economic, and political significance of such soil deterioration, little or nothing was known of the principles of fertilization until the early years of the nineteenth century. With the understanding of these principles came the birth of the fertilizer industry which at first dealt in naturally occurring materials and various animal and plant wastes, later supplemented by the byproducts of other industries. The modern chemical fertilizer industry began with the discovery in 1840 that the fertilizing value of bones was increased by their treatment with sulfuric acid and with the commercial application thereof for the production of dissolved bone and superphosphate.

Commercial mixed fertilizers are mixtures primarily of materials that contain the three fertilizing elements, nitrogen, phosphorus, and potassium. Until comparatively recent years, the United States was largely dependent upon foreign sources for its nitrogen and potassium and was self-sufficient only as regards phosphorus. Our enormous deposits of phosphate rock, which for years not only met our own demands for phosphorus for fertilizer purposes but also supplied those of many European nations, still suffice for all our anticipated needs in the near future. As a result of technological progress, a synthetic nitrogen industry, based on the utilization of the inexhaustible supply of the nitrogen in the air, has been developed, the capacity of which, together with our byproduct nitrogen capacity, is capable of expansion to supply all future needs, whether for fertilizers or explosives. The dearth of potassium during the period of the World War, resulting in a thousandfold rise in price, stimulated a successful search for native deposits of potassium salts. The discovery of large natural beds of these salts, coupled with the development of procedures to exploit them, and other sources of potassium in this country, has freed us from dependence on foreign monopoly for this element also.

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Supply Problem Arises

During the early years of the fertilizer industry the materials that were available to the fertilizer manufacturer for use in the production of commercial mixed fertilizers contained relatively little of the three elements considered of primary importance. The mixtures prepared from them were necessarily low in these elements. Low-grade materials, however, are characterized by high costs of transportation and handling relative to their plant-nutrient content. This disadvantage to their use resulted in a gradual increase in the concentration of many fertilizer materials that were already in use through improvements in methods of manufacture and the introduction of refining processes. With increasing consumption of commercial fertilizers and the resultant growth of the fertilizer industry, the more serious question of supply arose. A number of materials extensively used, such as cottonseed meal and tankage, were more and more diverted to use as feed for stock. In addition, the output of the industrial byproducts that found use in the fertilizer industry was dependent on the sale of the principal products and could not be increased independently to meet increased demands for the byproducts. The increased demands for fertilizer materials have therefore been supplied more and more by high-grade chemical products.

A corresponding increase in the concentration of the mixed fertilizers did not occur. The primary reason is the fact that the various grades of mixed fertilizers had become established when low-grade materials only were available and farmers continued through conservatism to demand these grades. Fertilizer manufacturers were compelled, as they gradually substituted higher grade for lower grade materials in the preparation of their mixtures, to use increasing quantities of inert materials or fillers to obtain the grades demanded. The chief causes for such rise as has taken place were (1) efforts of the manufacturer to sell higher grade fertilizer mixtures rather than to add increasing quantities of filler to his mixtures, (2) the educational campaign of agronomists and other officials of various agricultural experiment stations and of the United States Department of Agriculture to bring to the attention of farmers the savings accruing in the purchase of higher grade fertilizer mixtures and (3) the passage of laws in a number of States prohibiting the sale of fertilizers containing less than a minimum quantity of plant nutrients, a result of the efforts of the same officials. Nevertheless, mixtures containing double the content of nitrogen, phosphorus, and potassium in the fertilizer mixtures ordinarily sold can be readily prepared by the use of materials that have been made commercially available. Also, to meet the former objection that fertilizer distributors could not apply uniformly in the field the lesser quantities of such higher analysis fertilizers that would be required to supply the same quantities of plant nutrients, distributors have been devised capable of uniformly applying as little as 50 pounds of fertilizer per acre.

More Reliance on Chemistry

Failures to obtain favorable responses on some soils when mixtures of only nitrogen, phosphorus, and potassium are used have brought forcibly to attention the fact that plants require for their growth other elements also and that certain soils may be so deficient in one or more of these "minor plant foods" as

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to limit the size of the crop obtainable. As the fertilizer industry of the future relies more and more for its supplies of fertilizer materials upon products manufactured by chemical processes, increasing consideration will have to be paid to providing the secondary fertilizing elements in mixed fertilizers. This will have an influence in limiting the ultimate concentration of higher analysis fertilizers as regards the primary fertilizing elements. Although most fertilizers of the present day supply more calcium and sulphur than are needed on the majority of soils, large areas of our lighter soils would, within a comparatively short time, develop calcium and sulphur deficiencies if these elements were omitted from fertilizers. The addition of compounds of magnesium and manganese to fertilizer mixtures has already become quite extensive. Recent experiments have shown that the application of small quantities of other elements such as copper, zinc, and boron to certain soils considerably increases the crop yields thereon.

In consequence of the growing use of synthetic ammonia and ammonium compounds in fertilizers, attention has also been directed of late to the fact that fertilizer mixtures containing nitrogen in such forms only tend to make soils more acid in reaction and that continued application thereof finally causes the soil acidity to reach a point that affects growth of crops adversely. A method of calculation has been developed for determining the potential acidic or basic reaction of fertilizer materials. By use of the values thus obtained, fertilizer manufacturers can know in advance the potential reactions of their various fertilizer mixtures. Extensive progress has been made toward the production of mixtures that are non-acid-forming, particularly by the use of ground dolomitic limestone. The increasing necessity for use of neutralizing agents as well as need for provision of secondary plant-nutrient elements are factors that will probably limit the ultimate concentration of fertilizer mixtures as regards the three primary elements to the double-strength mixtures. Such mixtures, so adjusted as regards potential acidity or basicity and containing the secondary fertilizing elements best adapted to the particular soil and crop for which they are intended, will probably constitute the greater proportion of the fertilizer mixtures of the future.

Techniques of Application

Recent work has shown that the maximum benefits obtainable from the use of fertilizers are frequently not attained because of improper methods of application. Proper placing of fertilizers with respect to the seed both as regards closeness and relative location has been found to considerably enhance the increased yields. Too close proximity of a fertilizer to the seed is usually the sole cause of delayed germination, or even failure to germinate, as well as of injury to the young plants. The usual method of mixing the fertilizer with the soil in the row, practiced in many localities, is frequently a poor one. Methods of application best adapted to the different types of soils and kinds of crops are being gradually learned, and the knowledge thus acquired is being used for the designing of new fertilizer distributors and attachments, the increasing use of which is certain to enhance the average yields now obtained per acre with the use of fertilizers.

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Prevention of the segregation of the materials contained in mixed fertilizers that occur during the handling processes between the fertilizer factory and final lodgement in the soil is receiving attention. The extent to which this segregation takes place increases with differences in the sizes and specific gravities of the individual particles of the materials used to prepare the mixtures. As a result of segregation the composition of the mixture ceases to be uniform throughout so that, when the mixture is applied in the field, the same relative quantities of the different fertilizing elements do not become accessible to the roots of the individual plants. In consequence, a given plant may have at its disposal more of one of the fertilizing elements than it requires while it is not supplied with enough of another element for its full development. Methods of granulation have recently been devised which not only prevent segregation but also reduce the tendency of the mixtures to cake or become sticky and facilitate the process of their distribution to the soil.

Developments and improvements of fertilizers in the future have many important possibilities. Nationally, we have become self-contained as regards the elements on which we are dependent for the production of our future crops. As a result of new and cheaper methods of manufacture, the cost of these elements in fertilizer materials has been considerably reduced. Further savings are possible by using these fertilizer materials for the production of double-strength fertilizers. The employment of such double-strength mixtures, granulated, properly placed, and suitably adapted in composition to the soils and crops to which they are to be applied, will considerably increase crop yields per acre per unit of fertilizing element employed. The use of fertilizers will thus be made more profitable and their more general employment and in larger quantities per acre will result. The increased yields per acre obtained will encourage the withdrawal of lands now unsuited to cultivation and their sowing to grasses or their reforestation, and an intensification of the cultivation of the better suited lands with greater consideration given to the conservation of their fertility. In many farming sections the development and maintenance of pastures on the poorer land, with the aid of fertilizers, and cultivation of only a small portion of the land, will necessitate the expenditure of less labor on the part of the farmers in proportion to the financial returns.

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THIS MINNESOTA SEED GRAIN TREATER PROVIDES MEANS FOR EASILY DISINFECTING SEED ON THE AVERAGE FARM

EDITOR'S NOTE:- The device described and illustrated here was designed by Mr. M. B. Moore, Division of Plant Pathology and Botany, Agricultural Extension Division, University of Minnesota, University Farm, St. Paul, Minnesota. It was announced in a bulletin issued by the Extension Division, from which the information below is taken.

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An effective seed grain treater for use with dust fungicides has been devised which is so inexpensive and easy to make that there is now no reason why any farm should be without one. An understanding of its construction and use may be had from the figures on the following pages. Since the first publication of this description, a few changes have been made in some of the dimensions. These are included in these sheets and should be followed in preference to the earlier specifications.

Construction

Materials	Approximate retail prices in St. Paul
33 ft. of 1" x 10", No. 2 pine board (3, 12 ft.; 4, 10 ft.; or 5, 8 ft. boards)	$1.75
2 "T" hinges 6"	.20
2 "T" hinges 3"	.10
2 gate hooks 1½"	.05
1 lb. nails 2½", box	.05
3 doz. screws ¾", No. 8	.08
25 ft. sash cord or rope about 3/8"	.37
1 pulley 2½" - 3"	.25
	$2.85

In addition, 2 to 4 large shelf brackets may be required if the treater is to be set up on a table or wagon box.

Assembly

First cut all of the parts indicated in the plans given here. Next nail up the mixing chute, leaving the placing of the baffle boards to the last. The clean-out door may be placed on either side. The sides and door must overlap the front and back of the chute. Examine the plan carefully to see how this is done. Accurate cutting and placing of the baffles is of the very greatest importance. The upper edges of these are beveled to 45° to fit snugly against the inside of the chute. The grain of the wood should run from top to bottom. A 2" hole is bored in each baffle 2" from the top and ¾" from the right-hand edge. If a 2" auger is not at hand, a somewhat smaller (1¾" x 1¾") square hole may be cut with a chisel.

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Spacing of baffles: The upper edge of the top baffle is placed 17½" from the top of the chute. The rest come in order 24", 29½", 36", 41½" from the top.

Arrangement of baffles: This is important. The top baffle (8" x 8") is placed with its beveled edge running the same as the length of the proportioning trough and with the hole under the opening that will be made by raising the trough. The next baffle (6½" x 9½") is turned ¼ turn to the right so that part of the grain sliding from the first baffle will fall through the hole in the second. The third baffle (8" x 8") is turned another ¼ turn. The fourth and fifth baffles are similarly turned and placed.

Nails can be driven into each corner of the lower end of the chute, cut off, and filed to a point, and a wooden turn button provided to hold the grain sacks.

When the mixing chute is complete, study the way the proportioning trough will fit into it and how the two will be hinged together. When this is clear, nail up the trough, being careful to overlap the boards as shown. Finally, put the trough and chute together in the position shown, pushing the trough clear in to the front of the chute so that no opening is left into the chute unless the trough is raised. Hinge the two together in this position, using the two 6" "T" hinges.

The trough holds 2½ bushels, and it is planned to treat 2 bushels at a time. If a larger or smaller trough is desired, the required size may be calculated. One bushel contains 2,150 cu. in. Larger troughs when loaded may be found too heavy for easy handling.

Set Up

The machine may be mounted against the wall of the granary or on a table or wagon box. In any case, the bottom of the chute should clear the floor by the height of a grain sack, and there must be a table or platform to stand on when filling the trough. The free end of the trough is supported by a rope and pulley hung from the ceiling. In second floor granaries, cut a hole through the floor and make the chute longer, to reach down to the first floor. The trough rests directly on the upstairs floor.

Operation

To fill the proportioning trough, put in a bushel of grain, spread it out evenly, and over it sprinkle ½ oz. of New Improved Ceresan or the required amount of other dust disinfectant (Fig. 1, on plan). The dust should be spread evenly in a line down the center of the trough from one end to the other. Next add the second bushel of grain and a second dose of disinfectant. Three and 1/2 inches of grain in the trough equals 1 bushel, 7" equals 2 bushels. When the trough has been filled in this manner, dump the grain through the chute by raising the free end of the trough (Fig. 2, on plan). Catch the grain in bags to keep as much of the dust as possible from getting into the air. To observe the mixing effect of the machine, open the door and hold a pane of glass over the opening while the grain is flowing through the chute.

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Disinfectants To Use

New Improved Ceresan, ½ oz. to the bushel, controls the smuts of wheat, oats, barley, and rye, except the loose smuts of wheat and barley, controls barley stripe, reduces the amount of seedling blights in all four crops, and often benefits flax.

Merko and New Improved Semesan Jr., 2 oz. to the bushel, help to control seedling blight in corn. This disease is important when corn is planted early or on cold wet soil. Seed treatments do not control corn smut.

Copper Carbonate, 2 to 3 oz. to the bushel, controls covered smut of wheat, and rye smut.

The Minnesota Seed Grain Treater was designed primarily for treating small grains with New Improved Ceresan. However, the mixing seems better than had been hoped for, and it is possible that it can be used successfully with other fungicides and other crop seeds.

Precautions

1. Be absolutely sure when making the machine to cut and place the baffles correctly.
2. Fill the proportioning trough carefully as directed under heading, "Operation". The effectiveness of the treater depends upon these two points.
3. Clean treater before treating a different variety or crop.
4. Use the exact amount of disinfectant recommended by the manufacturer.
5. Don't breathe the dust; all fungicides are more or less poisonous. Work out-of- doors, or in a well ventilated room -- put in another window if necessary.
6. Wear a dust mask if treating much seed. Such a mask is useful for many other farm jobs.
7. Wash the hands and face after work and before eating.

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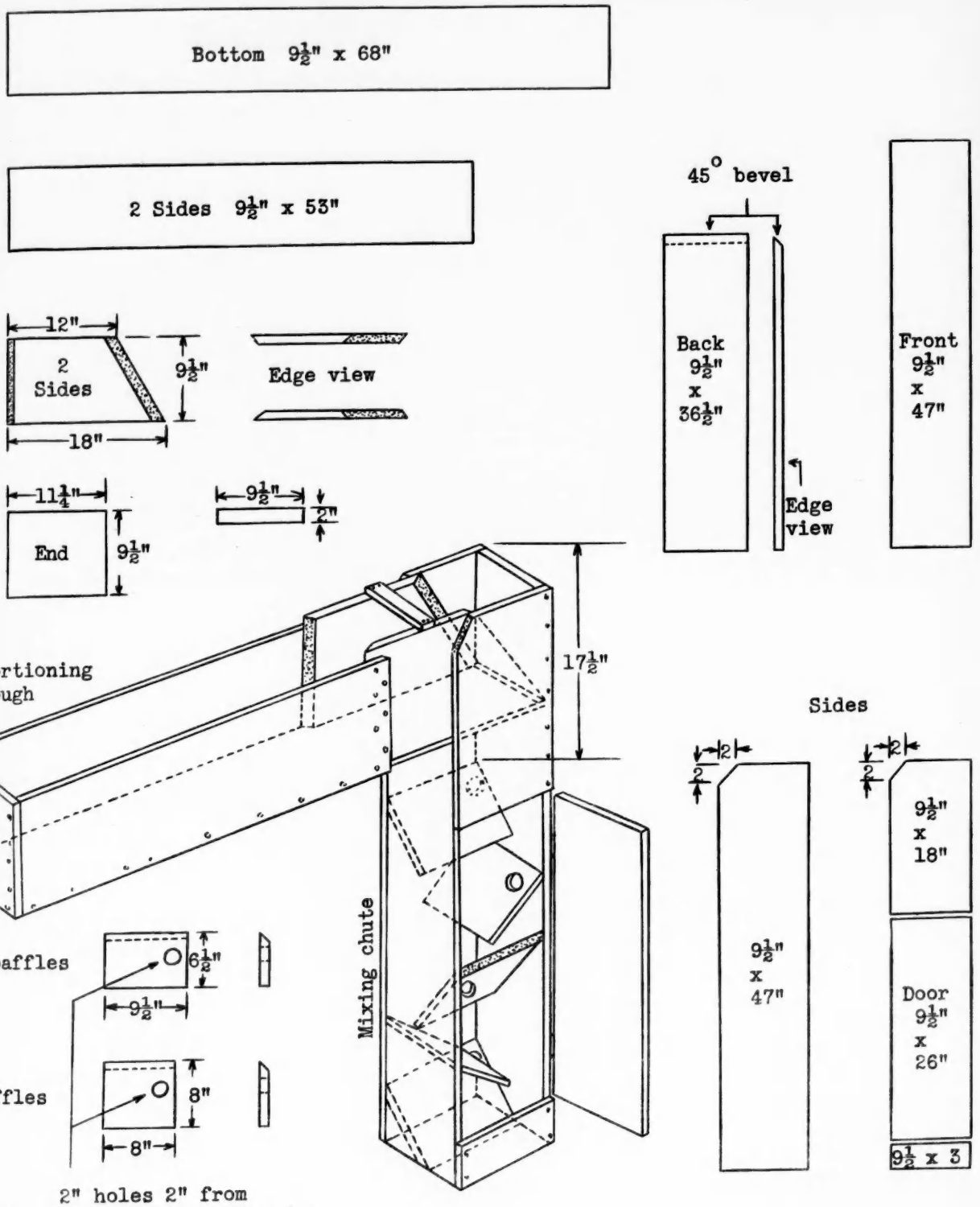
"Ceresan" and "Semesan" are trade names registered in the U. S. Patent Office by the Bayer-Semesan Company, Wilmington, Delaware.

Plans for Construction

Parts for proportioning trough

Parts for mixing chute



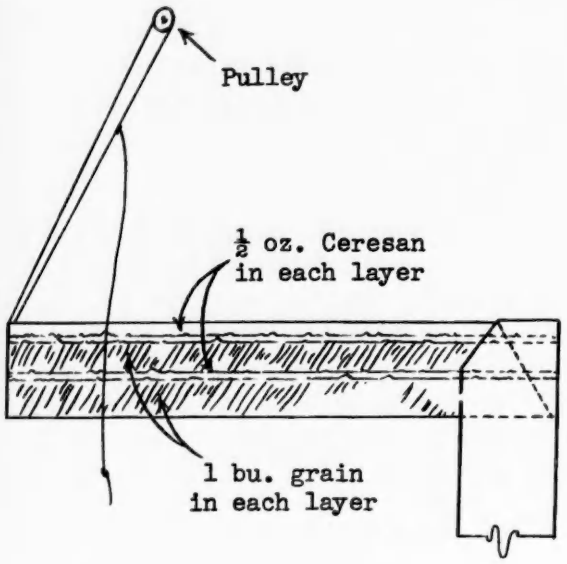


Fig. 1. Manner of filling proportioning trough

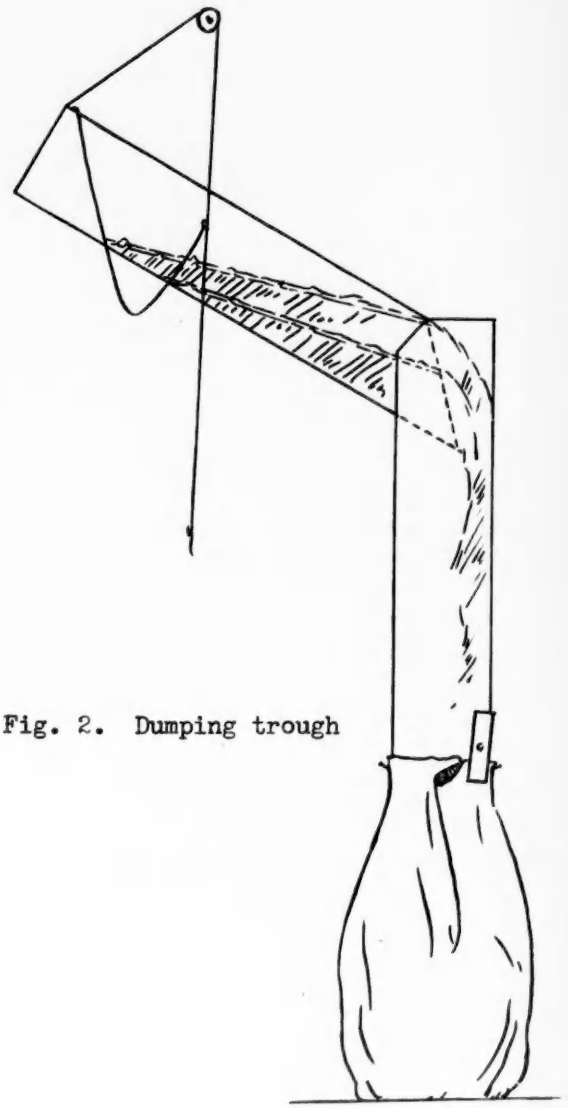


Fig. 2. Dumping trough

METHYL CHLORIDE SHOWN TO BE A PRACTICAL REFRIGERANT WHEN MEASURED BY THE ACCEPTED THEORETICAL STANDARD

EDITOR'S NOTE:- There is presented here the second part of a summary of a paper on methyl chloride as a refrigerant. This paper was read at the 42nd Spring Meeting of the American Society of Refrigerating Engineers, French Lick, Indiana, June 10, 1937. The first part appeared in the August issue of this publication. Those concerned with the preservation of agricultural products in storage will find the information given of interest and value. The summary will be concluded in the October number.

By E. W. McGovern, Refrigerating Engineer,
The R. & H. Chemicals Department,
E. I. du Pont de Nemours & Company, Inc.,
Wilmington, Delaware.

Let us consider the listed criteria of the ideal refrigerant (See August issue) in more detail and see how methyl chloride and to some extent other refrigerants measure up to them.

1. Stability: A refrigerant should not decompose at any temperature that may be encountered in the refrigeration system. Further it should not polymerize, forming higher boiling or solid substances.

All of the refrigerants in common use today show satisfactory stability in the absence of substances foreign to a refrigeration system, since stability is an absolutely necessary requirement of a refrigerant. Methyl chloride is thermally stable up to about 800°F., a dull red heat, and it does not polymerize.

2. Corrosiveness and Solvent Properties: A refrigerant should be chemically inert and exhibit no solvent power toward any material of construction with which it may come in contact. This includes metals, gaskets, and, in the usual hermetic units, varnishes, motor windings and insulating materials.

Action on metals. In the absence of moisture, methyl chloride is non-corrosive to all common engineering metals. However, zinc, aluminum, die castings and possibly magnesium alloys should not be used in contact with it as these are strongly attacked in the presence of small amounts of moisture. All refrigerants in use are non-corrosive to common engineering metals in the absence of moisture. All with the probable exception of unsubstituted hydrocarbons such as ethane, propane and isobutane, when in the presence of moisture sooner or later show greater corrosive effects than would be obtained from water alone. For this and other reasons the moisture content of methyl chloride

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should be low, although it possesses a very important advantage, especially over sulfur dioxide, in that moisture may be present but will do little or no harm if removed in a reasonable period of time and further, in that moisture may be easily removed by installation of chemical dryers on the refrigeration equipment.

Gaskets. Methyl chloride is a solvent for many organic materials and composition gaskets must be selected carefully. In general they should not contain rubber and many neoprene compositions cannot be used. Pressed fibers including asbestos, with a number of insoluble binders may be used, as may also metallic gaskets. All refrigerants in use may be gasketed satisfactorily although special problems may be presented.

Motor windings, insulator materials, varnishes, etc. Hermetically sealed units embodying an electric motor running in the presence of refrigerant and oil present special problems. Obviously such systems must be dry, if only to prevent short circuits, and the refrigerant itself must not conduct electricity. Methyl chloride is very satisfactory from the standpoint of conductivity and is successfully used in hermetic units. Problems with hermetic units are in general the same with all refrigerants although they may differ in details.

3. Volume (Piston) Displacement: For reasons of compactness, reduction of friction area and friction loss, reduction of piston stroke, reduction of area for slippage of gas past compressing element from high to low side and reduction of compressor speed, the volume of gas which must be compressed per unit of time for a given refrigeration effect should in general be as low as possible. An exception to this is in the case of refrigerants for lower tonnage centrifugal compressors where, at least with existing designs, volume of gas handled should be comparatively large. Low volume displacement is unimportant in the case of some low capacity, high speed rotary compressors.

Methyl chloride has a relatively low volume displacement, which adapts it for use in reciprocating compressors ranging from the smallest sizes to machines of up to twenty tons capacity. This includes compressors for household and commercial refrigeration.

4. Condensing Pressure: Condensing (high side) pressure should be low so as to allow of light weight equipment which in turn affects initial cost, power consumption (heavy moving parts), compactness and installation problems. High pressure increases the tendency toward leakage on low side as well as high side, when pressure is built up during shut down periods, and in addition to reasons of economy, is very important from the standpoint of toxicity and fire hazard.

Methyl chloride presents a nice balance between volume displacement and condensing pressure, the latter being 81 lb./in.$_2$g. at 86°F. Extra heavy construction is not required so that there is little or nothing to be gained from the standpoint of weight of equipment in using a lower pressure refrigerant.

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5. Evaporating Pressure (Boiling Point): Evaporation (low side) pressures above atmospheric pressure are desirable to avoid leakage of moisture laden air into the refrigerating system and to permit easier detection of leaks. This is especially important with unsealed units. Air increases head pressures resulting in inefficient operation or complete cessation of refrigeration. Moisture causes corrosion, may result in harm to lubricant, and may freeze out and stop operation of the equipment.

In general, the higher the evaporation pressure, the higher the condensing pressure under a given set of temperatures and, therefore, in order to keep head pressures at a minimum and still have positive low side pressures, the refrigerant selected should have a boiling point at atmospheric pressure as close as possible to the lowest temperature to be produced under ordinary operation conditions. Methyl chloride with a boiling point of -10.65°F. is close to ideal in this respect for the bulk of refrigeration applications. A still lower boiling point is of some advantage only if and when lower operating temperatures are wanted.

6. Freezing Point: Freezing point of a refrigerant should be below any temperature that might be encountered in machine operation. Freezing points of all refrigerants except water (32°F.) and carbon dioxide (-69.9°F. triple point) are far below temperatures that might be encountered in their use even if they had lower freezing points. Methyl chloride has a freezing point of -144°F.

7. Critical Temperature: The critical temperature of a refrigerant, the highest temperature at which it can be condensed to a liquid regardless of higher pressure, should be above the highest condensing temperature that might be encountered. With air cooled condensers this would be above about 130°F.

Losses of efficiency with various refrigerants as occasioned by superheating on compression and throttling expansion of liquid are higher when operating near the critical temperature.

All common refrigerants have satisfactorily high critical temperatures except carbon dioxide (88.2°F.) and ethane (89.9°F.) and these refrigerants require condensers cooled by water at a temperature below their respective critical temperatures.

8. Latent Heat of Evaporation: A refrigerant should have a high latent heat of evaporation per unit of weight so that weight of refrigerant circulated to produce a given refrigeration effect may be small, and to keep at a minimum, for the sake of safety and cost, the required weight of refrigerant charge in a system. Latent heat is even more important when considered in light of its relation to volume of liquid required and net refrigerating effect, but as other factors enter into the determination of these, they are discussed separately.

Methyl chloride with a latent heat of evaporation of 179.0 at 5°F. stands high in this factor among refrigerants in common use.

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9. Specific Heat of Liquid and Net Refrigerating Effect: Low specific heat of liquid is desirable in a refrigerant. If the ratio of latent heat to specific heat of liquid is low, a relatively high proportion of the latent heat may be required and used in lowering the temperature of the liquid from condenser temperature to evaporator temperature. This results in a small net refrigerating effect per pound of refrigerant circulated and, assuming other factors remain the same, reduces capacity and lowers efficiency. When ratio of latent to specific heat is very low, it is often advisable for the sake of capacity and economy to precool the liquid before evaporation by heat interchanging with the cool gases leaving the evaporator. This, of course, ordinarily raises the temperature of gas entering the compressor and the compressed gas then carries more than the normal amount of superheat, necessitating larger condenser surface than without the interchanger and increasing work of compression.

The net refrigerating effect per pound of methyl chloride is relatively high; methyl chloride has high ratio of latent heat to heat of liquid.

10. Specific Heat of Vapor-Power Consumption: In the conventional refrigeration cycle gas is superheated on compression, work of compression increases as the amount of superheat on compression increases. Since high superheat is associated with low specific heat of vapor (Cp), it follows that a high specific heat of vapor is desirable to reduce superheat work loss.

Generally a high Cp of gas accompanies a high specific heat of liquid so that expansion and compression losses add up to about the same amount for refrigerants operating well below their critical temperatures.

Factors affecting expansion and compression losses of course increase in importance when latent heat and net refrigerating effect are low, the ratios of the specific heat factors to latent heat rather than either of these factors alone are most important in determining differences in coefficient of performance, efficiency and power requirement of various refrigerants.

11. Density, Gas and Liquid: Densities of the ideal refrigerant in gas and liquid states would be low. Pressure drop in passing a given volume of fluid through orifices increases with increased density as well as with increased viscosity. If efficiency is not to be impaired, orifice openings and tubing must be increased in size so that pressure drops are not excessive. This increases cost of equipment and may involve engineering difficulties due to space limitations. This fluid flow disadvantage of a high density liquid is offset when refrigerating effect per pound is comparatively high, since higher density then results in comparatively lower volume circulated.

When condensing unit and evaporator are located on different levels, a low density of liquid is desirable so that the pressure (power) required to raise the head of liquid may be a minimum.

Cost per pound being the same, high density liquids cost more per unit of volume and, in general, charges of equal volume rather than of equal weight are required of different refrigerants for various applications.

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In general, the higher the evaporation pressure, the higher the condensing pressure under a given set of temperatures and, therefore, in order to keep head pressures at a minimum and still have positive low side pressures, the refrigerant selected should have a boiling point at atmospheric pressure as close as possible to the lowest temperature to be produced under ordinary operation conditions. Methyl chloride with a boiling point of -10.65°F. is close to ideal in this respect for the bulk of refrigeration applications. A still lower boiling point is of some advantage only if and when lower operating temperatures are wanted.

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Generally a high Cp of gas accompanies a high specific heat of liquid so that expansion and compression losses add up to about the same amount for refrigerants operating well below their critical temperatures.

Factors affecting expansion and compression losses of course increase in importance when latent heat and net refrigerating effect are low, the ratios of the specific heat factors to latent heat rather than either of these factors alone are most important in determining differences in coefficient of performance, efficiency and power requirement of various refrigerants.

11. Density, Gas and Liquid: Densities of the ideal refrigerant in gas and liquid states would be low. Pressure drop in passing a given volume of fluid through orifices increases with increased density as well as with increased viscosity. If efficiency is not to be impaired, orifice openings and tubing must be increased in size so that pressure drops are not excessive. This increases cost of equipment and may involve engineering difficulties due to space limitations. This fluid flow disadvantage of a high density liquid is offset when refrigerating effect per pound is comparatively high, since higher density then results in comparatively lower volume circulated.

When condensing unit and evaporator are located on different levels, a low density of liquid is desirable so that the pressure (power) required to raise the head of liquid may be a minimum.

Cost per pound being the same, high density liquids cost more per unit of volume and, in general, charges of equal volume rather than of equal weight are required of different refrigerants for various applications.

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Denser refrigerants tend to place higher starting torques on motors.

Methyl chloride shows relatively low densities (relatively high specific volumes) of both liquid and vapor.

12. Volume of Liquid Circulated: Volume of liquid required to be circulated for a given refrigeration effect should be low, to avoid fluid flow (pressure drop) problems and to keep down the size of the required refrigerant charge; a system charged with a refrigerant having a large cooling effect per unit of volume has more reserve to take care of sudden heavy loads and the same factor along with good heat transfer and low operating temperature appears to be related to quick freezing qualities.

Volumes of methyl chloride circulated are not excessive and at the same time are not so low as to interfere with accurate control in the smallest capacity systems. Satisfactory control in small systems is obtained with sulfur dioxide with lower volumes circulated. Ammonia, however, with still lower volumes presents a more difficult control problem for application to small machines.

13. Viscosities, Gas and Liquid (Fluid flow factors): To keep pressure drops, or sizes of tubing, orifices and valves, at a minimum, viscosities of both gaseous and liquid refrigerant should be low. Viscosities of methyl chloride are satisfactorily low under operating conditions. Low viscosities also contribute toward good heat transfer.

Pressure drops or orifice sizes are dependent upon volumes circulated and densities (specific volumes) as well as viscosities.

14. Heat Transfer Characteristics: Refrigerants showing high heat conductivity and high film coefficients are desirable so that efficient use of evaporator and condenser surface may be made. Good heat conductivity is necessary for quick cooling characteristics. Low viscosities, solubility of refrigerant in oil and high fluid velocities (if allowable without excessive pressure drop) increase heat transfer characteristics in actual operation.

Complete comparative heat transfer data for the various refrigerants are not available but actual practice has shown methyl chloride to have excellent overall heat transfer characteristics, being among the best of the commonly used refrigerants in this respect and, therefore, requiring comparatively low condenser and evaporator surfaces for given application.

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RESEARCH RECOGNIZED AS ESSENTIAL IN DEVELOPING PROGRAM FOR THE RESTORATION AND MANAGEMENT OF WILDLIFE SPECIES

EDITOR'S NOTE:- The approach to a solution of the wildlife problem, as set forth in this excellent article is certain to provoke serious and constructive thinking on the part of all interested in the subject. The writer points out that more important than what man requires of wildlife is what wildlife demands of man, if the species are to continue to exist. Research is shown to be an essential factor in any program for the betterment of the present situation.

By Ira N. Gabrielson, Chief,
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Since the beginning of the conservation movement, which originated largely in the realization that the wildlife with which this continent was endowed was melting away like a snow bank in a summer sun, we have seen legislation based on the cry "this is what the sportsmen want." Some times these movements have been good--more often bad--based as they were on personal beliefs or blind faith in some magic formula in restoring their vanishing shooting privileges.

We are commencing to learn, and sportsmen in ever-increasing numbers are coming to believe, that the only sane way to handle wildlife resources is to make laws and regulations for the needs of the wildlife--be it birds or animals.

The question is immediately raised, what are the needs of wildlife? What does it need in the way of food, cover, and protection from natural enemies, and what is the solution for a host of other problems? How much wildlife will our land support and still produce the things the human race demands of the land? There is only one way to get the answer: study the animals and birds involved. This requires time, energy, and patience far beyond the casual observations of a hunting trip or a few days spent afield in the summer. There is no magic about it--just a lot of painstaking effort to gather facts rather than theorize, and then fit the facts together into an understandable pattern. This is wildlife research.

Some Practical Results

To the extent that research succeeds, our wildlife program can be based on solid facts and have a greater chance to produce results. A few concrete examples will perhaps bring out the point more clearly. It required years of study and painstaking research to learn that duck sickness is produced by the toxins formed by a botulinus organism growing under certain conditions of water, temperature, and chemical mixtures when quantities of decaying vegetable or animal matter are

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present. What good did it do? It taught us the process by which this devastating disease reached epidemic stage. Knowing the process, we are now able to attack the problem intelligently, and where it is possible to control or manipulate water supplies, the outbreaks can be prevented or the losses greatly reduced. This is a practical value attached to research.

The vast accumulation of information on food of birds and mammals gathered through fifty years of studies by a long line of scientific men has proven invaluable to the wildlife restoration movement now sweeping the country. Scores of pamphlets and mimeographed lists of plants valuable for various wildlife species have provided guidance to Federal, State, and private agencies. This information has proven useful in connection with programs for soil-erosion control, reforestation, and marsh-restoration, as well as to literally thousands of individuals taking heed of the needs of some form of wildlife.

The bird-banding operations of the Biological Survey, carried on by the help of thousands of individuals scattered over this continent, was started and carried on for years as a purely scientific study of migration. Yet the information developed from these studies has made it possible to map the major flyways on the continent, the major waterfowl concentration points, and the intricate movements of these birds so accurately that it has been of major importance in staking out a great national system of waterfowl refuges.

Likewise the many studies of the chemical and physical variations of waters, the different types of bottom, and the effects of currents and tides, in relation to growth of aquatic plants became of immediate practical value when we undertook to restore in the shortest possible time millions of acres of marsh lands.

Research revealed that quail failed to stay on thousands of acres of otherwise suitable area in the Middle West because all the plants and shrubs that could furnish shelter from wintry weather and natural enemies had been removed. Where such cover is restored the quail come back. In other more southern areas where cover was plentiful a shortage of winter food was revealed by research to be a great limiting factor. Planting of suitable seed-bearing plants has remedied this on thousands of acres and produced a greater stock of birds.

Research has taught us the inescapable truth that browsing animals can literally eat themselves into starvation by destroying the plants on which they feed. It has thus driven home the fact that limitation of numbers of wildlife may be just as important in one area as increasing its numbers is necessary somewhere else.

The carefully worked out studies of plant abundance and distribution in certain lakes in Nebraska, the Dakotas, and Minnesota, which were undertaken years ago as purely ecological studies, have assisted materially in the program of lake restoration now going forward in those States. This information, together with the constantly increasing knowledge of the part played by chemical composition of water, the amount of salt carried, current, and type of bottom is making it possible to shorten by years the restoring of these lakes and marshes to the old productive conditions.

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Facts Essential to Progress

A constant search after facts and yet more facts--a process which will be continual because of constantly changing conditions--is the only hope of an intelligent handling of our wildlife resources whether that resource be fish, fowl, or beast.

We must know the facts--must produce the conditions needed by wildlife and then limit the human harvest to the surpluses above necessary breeding stock that can be produced. This is the only possible way, and research must supply the answers if we are to continue to have many of our finest forms of wildlife in any abundance.

These are some of the considerations that give great importance to the recently established units at nine land-grant colleges for wildlife research, demonstration, and education. There should be more of these untis. Their program of fact-finding, fact-demonstration, and fact-broadcasting is a revolutionary one in the history of American wildlife conservation. It offers in my opinion one of the greatest forward steps that has ever been taken. They represent the greatest development to date of the plans for basing an adequate wildlife restoration program on the true foundation of research.

CHOICE OF FORM OF POWER A PROBLEM FOR ENGINEER TO SOLVE IN RELATION TO EFFICIENCY AND ECONOMY

EDITOR'S NOTE:- Mr. Livingston deals with fundamentals in this discussion of the advantages, disadvantages and indispensability of mechanical equipment for construction purposes, including agricultural operations. Of equal importance are his suggestions for giving consideration to dynamite as a highly useful source of power. Comments will be appreciated by the editor.

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Obviously, an engineer to be efficient must understand where and when to use any and all kinds of power. He must decide what type of power is most economical and satisfactory to use for any particular job.

As every engineer understands, the cylinders, pistons, valves, gears and wheels of a steam engine are of use only in making available the energy developed by the consumption of coal or some other fuel. An engine, he knows, adds nothing to power; rather, it uses some of it in harnessing power so that it may be made to do useful work. Similar considerations apply in the cases of the internal combustion engine and electric motor. In turn, the power "output" of a prime mover is useful only when it is applied to a piece of machinery of some sort, by which work is done. Steam, gasoline, and electric power, therefore, fall within the "indirect" classification.

It is hardly necessary here to go into details as to the amount of money that can be tied up in mechanical equipment for construction purposes. Maintenance costs, depreciation and interest on investment must likewise be considered. Such expenditures, however, are justified where through use equipment returns profit or even earns its "keep."

There is also to be considered the fact that mechanical equipment must be moved to and from the work to be done. Naturally, expense is involved. In addition there are fuel costs and the wages of operators. But, patently, there are many kinds of work that can be done only by mechanical means. Under many conditions machinery can do work at less cost than it can be done in any other way.

Dynamite as a Source of Power

Everybody knows that dynamite is an explosive. But comparatively few think of dynamite as a source of power, such, in a sense, as steam or electricity.

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Only a few years ago, even engineers were all too frequently prone to consider the use of dynamite only as a last resort. Manual labor or machinery was the first thought, as a rule, when a job was to be done. That situation was probably due in part to lack of teaching of the theory and practice of blasting in most of the engineering schools, with the notable exception of those devoted to mining courses.

Engineers now recognize the fact that dynamite represents concentrated power, and that it is all potential power. To make the tremendous power of dynamite available requires only proper loading and the detonation of the explosive with a blasting cap. There is no need for gears, pulleys, wheels or any of the other appurtenances of mechanical equipment. In short, the power provided by dynamite is "direct" power.

Control of Power Units to Suit Purpose

Dynamite offers the further advantage of unit power, which can be multiplied as many times as may be desired. This explosive can provide more power, by using the necessary number of units (sticks of dynamite), than could any engine or other piece of machinery it is possible to build. It can, in fact, supply practically unlimited power. On the other hand, the power of dynamite, of course, is not a continuous form of power, such as that of an engine or a motor. But there is no need for the action of dynamite to be continuous for the many purposes to which the explosive is applicable.

Usually, investment in dynamite is made at the time the explosive is to be used, with the result that there is no "overhead," such as interest. Maintenance cost and depreciation charges are obviated.

Another important consideration is that dynamite is extremely mobile. While there is transportation cost to move dynamite to the work to be done, it does not have to be removed after the job is completed. It is, however, true that storage facilities must be provided in the form of a magazine. Ordinarily, a safe and adequate magazine can be constructed in the field at little cost. The wages of blasters constitute an item of cost where dynamite is used, to be sure.

More frequently than is generally realized, dynamite can be used in conjunction with machinery and at considerable savings in cost and time.

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